



Transportation Synthesis Report

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Electronic Billboards and Highway Safety

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Transportation Synthesis Reports (TSRs) are brief summaries of currently available information on topics of interest to WisDOT technical staff in highway development, construction and operations. Online and print sources include NCHRP and other TRB programs, AASHTO, the research and practices of other state DOTs, and related academic and industry research.

REQUEST FOR REPORT

Advances in outdoor display technology, and decreases in cost, support an interest in expanding deployment of high resolution and dynamic imaging in outdoor advertising. Technology has advanced sufficiently for electronic billboards (EBBs) to provide dynamic and realistic views much like color television. The advanced EBB has the capability to present multiple views and objects that have realistic motion. In contrast, tri-vision signs provide one of three views with rotating cylinders and generate mechanical motion or movement.

This raises questions about the effects that EBBs and tri-vision signs may have on driver distraction and highway safety. The RD&T Program was asked to report on the measured or predicted safety impacts of outdoor electronic advertising signs.

SUMMARY

We located two FHWA resources that are especially helpful for getting familiar with the issues: the Office of Real Estate Services (ORES) Web site and the study entitled *Research Review of Potential Safety Effects of Electronic Billboards on Driver Attention and Distraction*. We provide links to the items and excerpts below, in the **Overview** section. The study affords an in-depth look at how states are regulating electronic outdoor advertising, from lenient control at one end to the prohibition of outdoor advertising at the other. Wisconsin addresses the issue with rules for the content, timing and brightness of EBBs and tri-vision signs. See **Wisconsin Regulations**. However, standard billboard guidelines governing EBBs and tri-vision signs do not exist: few states, in fact, define the term "electronic billboard." See **State and Local Studies**. Research on the issue of electronic ads causing driver distraction would suggest that the jury is still out. While some studies conclude that extra-vehicular distractions cause crashes, it has proven difficult to identify and measure the role of electronic advertising in driver distraction. See **Driver Distraction**. However, promising methodologies have been proposed for focused study of the issue, and for trimming the risk of driver distraction from electronic advertising. See **Avenues for Research**.

OVERVIEW

Outdoor ad spending in the U.S. rose 8 percent in 2000 to \$5.2 billion. Advanced electronic billboards will explode, according to one industry specialist, in towns with "street excitement and extravaganza" like Orlando, Las Vegas,

Hollywood, wherever large numbers of people congregate, though laws and safety issues may keep them off most highways.

A few years ago cities like New York and Los Angeles embraced what Hollywood's zoning department calls "jumbotrons" as a rejuvenating tool for shabby crossroads, but now cities are demanding tighter regulations. Los Angeles, a driver's city, wants hours of dimming. Many in the advertising sector see the light-emitting diode sign as the future of outdoor billboards. LED screens that recently debuted on L.A.'s Sunset strip bombard passing motorists with movie trailers, commercials and music videos. (From *The Clock* magazine, April 2001: http://www.theclockmag.com/acrobat/minute_by_minute.pdf)

A detailed history and overview of the federal outdoor advertising control program can be found on the FHWA's Office of Real Estate Services (ORES) Web site: <http://www.fhwa.dot.gov/realestate/oacprog.htm>. In a July 1996 memorandum to FHWA regional administrators, ORES provided additional interpretation of advertising technology to the individual states regarding off-premise changeable message signs: "Changeable message signs are acceptable for off-premise signs regardless of the type of technology used, if the interpretation of the State/Federal agreement allows such signs." In 1998, ORES reaffirmed its policy that off-premise signs using animated or scrolling displays that are dependent on flashing, intermittent or moving lights were not conforming signs. This decision was made after careful review of a videotape showing a full-motion EBB erected in Scottsbluff, Nebraska. It was concluded that such signs raise "significant highway safety questions because of the potential to be extremely bright, rapidly changing and distracting to motorists."

A majority of states have policies regarding the lighting of billboards; these policies have the effect of regulating EBBs.

A helpful overview of the EBB and tri-vision sign issue is provided in the study *Research Review of Potential Safety Effects of Electronic Billboards on Driver Attention and Distraction* (FHWA, Sept. 11, 2001-<http://www.fhwa.dot.gov/realestate/elecbbbrd/elecbbbrd.pdf>). This report is a research review of potential safety implications of EBBs on driving safety. It covers the interval since a similar review was published in 1980. The study focuses on the safety aspects of EBBs and does not examine aesthetic issues. Included are a review of research on driver performance in the presence of EBBs and contacts with federal and state officials to describe state regulatory practices concerning EBBs. An account of tri-vision signs is a part of the state review. Knowledge gaps are identified based on the literature review and these gaps support the development of a set of research questions and related research findings.

From the report:

- (p. 8) Determining the effect of roadway commercial advertising billboards on safety is a difficult endeavor for several theoretical and methodological reasons.
- (p. 9) Summary of a 1994 WisDOT study examining crash rates on I-94 three years before and three years after the installation of a variable message advertising sign.
- (p. 20) At this point, it appears that there is no effective technique or method appropriate for evaluating the safety effects of EBBs on driver attention or distraction.
- (p. 19) One approach being developed for in-vehicle information systems may serve, with some refinement, as a measure of EBB distraction.
- (p. 13) Although the CMS is restricted to providing roadway related information, its legibility requirements may be relevant to the design of the simpler EBB.
- (p. 29) Although research into in-vehicle cellular telephone use does not currently appear to have direct application to EBBs or tri-vision signs, these analyses are ongoing and may still provide insights into the nature of driver distraction, the definition of distraction thresholds and approaches to minimizing distraction for safe driving.

A study performed for the South African National Roads Agency Limited (SANRAL) looks closely at the matter of *content* regulation for outdoor advertising. SANRAL promulgated regulations on outdoor advertising and control in December 2000. In applying the regulations, several problems were experienced with the evaluation of content. The study was launched to investigate an analytical approach to evaluating advertisement contents based on driver characteristics. A parallel is drawn between the reading of road signs and the reading of outdoor advertisements. A

concept of the critical zone—the 500 meters in front of an advertisement—is developed, and the control of content in this zone is quantified. Rules are proposed to evaluate the content for advertisements that are intended to provide “a more practical, defensible approach to evaluating the content of outdoor advertisements.” The report can be viewed at <http://www.its-traffic.co.za/publications/SANRAL%20face%20evaluation%20presentation.pdf>

WISCONSIN REGULATIONS

Chapter Trans 201 of the Wisconsin Administrative Code states the rules that control outdoor advertising along and visible from highways on the interstate and federal-aid primary systems. Sections of the chapter that will interest readers of this report may be found at <http://www.legis.state.wi.us/rsb/code/trans/trans201.pdf>, including:

Trans 201.05 – Directional and official signs.

Trans 201.06 – Sign criteria.

Trans 201.19 – On-property signs.

Trans 201.15 – Electronic signs. This section sets standards for the use of signs whose messages may be changed by electronic process. Rules are defined for content, timing and brightness for multiple message (tri-vision) signs, and variable message (EBB) signs. The guidelines include:

Tri-vision signs

- The louver rotation time to change a message shall be one second or less;
- The time a message remains in a fixed position shall be six seconds or more.

EBBs

- No message may be displayed for less than one-half second;
- No message may be repeated at intervals of less than two seconds;
- No segmented message may last longer than 10 seconds;
- No traveling message may travel at a rate slower than 16 light columns per second or faster than 32 columns per second;
- No variable message sign lamp may be illuminated to a degree of brightness that is greater than necessary for adequate visibility.

STATE AND LOCAL STUDIES

The safety and aesthetics of commercial electronic variable message signing were reviewed by the FHWA in 1980.¹ Part of that effort included a review of published studies on the safety effect of roadside advertising signs, including several field and laboratory studies from 1951 to 1978 on non-electronic advertising billboards, and one analysis in 1976 of an electronic advertising sign in Boston. Among the findings:

1961: A study of California Route 40 concluded that road segments with billboards experienced significantly more crashes than segments without billboards.

1967: A field study compared the crash history of three locations in Chicago before and after the installation of three illuminated, commercial changeable message signs. Crash rates did not change at two of the sign locations, but the third sign location showed an increase in crashes. The third sign had alternating lights, showed several advertising messages and was illuminated by bright white lights. The rapid increase in crashes led state highway officials to request that blue lights replace the white lights.

1976: The Tele-Spot sign in Boston was an off-premise commercial electronic sign. The sign was visible from the Central Artery in the midst of complex on- and off-ramps, regulatory signs and guide signing. The Massachusetts Outdoor Advertising Board conducted an analysis of traffic crashes three years before and two and a quarter years after sign installation. The analysis showed an overall reduction in the Average Daily Traffic (ADT) and crashes along the expressway, but on the areas of the expressway from where the Tele-Spot was visible, the crash reduction was 10 percent less than the overall reduction. The board regarded the 10-percent difference as an indication that the Tele-Spot sign was a distraction and a safety risk, and consequently revoked the license for the sign.

¹*Safety and Environmental Design Considerations in the Use of Commercial Electronic Variable-Message Signage*
Wachtel, J. and Netherton, R. [1980]
Report No. FHWA-RD-80-051. Washington, D.C.: Federal Highway Administration)

Regarding tri-vision signs, a 1999 survey sponsored by and presented at the annual National Alliance of Highway Beautification Agencies (NAHBA) Conference reviewed the advertising regulations for these signs in every state and Washington, D.C.:

- Nine states (18 percent) had no regulations on tri-vision signs.
- Nine states had regulations on tri-vision signs that were either being drafted or in pending legislation.
- Nine states had specific regulations governing tri-vision signs.
- Six states as well as Washington, D.C. prohibited tri-vision signs.
- Fifteen states had regulations regarding moving parts and/or lights.

The survey presented the Minimum Exposure Dwell Time and Maximum Transition Twirl time boundaries of several state tri-vision sign policies.

Overall, while common themes are present in most lighting regulations, each state's laws have unique wording. A review of state outdoor advertising regulations conducted for the 2001 FHWA study revealed that common billboard guidelines governing EBBs and tri-vision signs do not exist. While the 42 states reviewed generally have consistent regulations governing static billboards, regulations covering EBBs and tri-vision signs vary widely, and implementation practices differ significantly from state to state. Few states define the term "electronic billboard." A broad spectrum of regulations exists, ranging from lenient control to the prohibition of outdoor advertising.

Included in the findings:

- Only 10 of the 42 states (24 percent) prohibit moving or animated parts in signs, unless the signs are a public service announcement. A few states make an exception for movement related to the changing of a sign.
- Twelve states (29 percent) include some type of timing limit for the viewing of signs. Of these, only eight apply to EBBs or other types of signs with changing messages.
- Most states (36) prohibit signs that include a red, flashing, intermittent or moving light, unless it is a public service display.
- Most states (36) prohibit signs that are not sufficiently shielded to prevent beams or rays of light from causing a glare or vision impairment that affects driver vision.

Based on the review, the report identifies the following issues that may pertain to EBBs: red, flashing, intermittent or moving lights; glare; use of traffic control device (TCD) symbols and words; illumination or placement interfering with a TCD; and spacing and timing limits. Of the potential issues, timing limits may be the one issue where additional or expanded research would have the most significant benefit.

In more recent developments:

- Focusing on transportation and tourism in Vermont, Brian Searles, Secretary of the Vermont Agency of Transportation, said that the state's biggest challenge is to resolve the clash between providing appropriate development of transportation infrastructure and retaining natural beauty. Tourism is an international business for the state, responsible for \$4 billion annually. Because 80 percent of tourists travel by car, he said that the state has eliminated roadside billboards, controlled development at interchanges, and applied flexibility in bridge design. (From AASHTO Weekly Transportation Report June 1, 2001: <http://www.aashto.org/publications/journal.nsf/SearchSite/75D49BC8E9D64BF086256A8B00088B72?OpenDocument&Highlight=billboards>. Scroll down to section on Transportation Ties to Agriculture, Recreation Examined.)
- The Oregon Department of Transportation proposed to amend the Highway Beautification Federal/State Agreement of Aug. 26, 1974, between the U.S. and the State of Oregon, to permit the use of tri-vision signs adjacent to routes controlled under the Highway Beautification Act. (From AASHTO Regs Report Aug. 22, 2001: <http://www.aashto.org/publications/regs.nsf/SearchSite/1CE55B45DD85BC1D86256AB0006C202C?OpenDocument&Highlight=outdoor%20advertising>)
- Legislation was approved by the Arizona House of Representatives to permit billboards to have 200-square-foot sections with lighted messages that change every six seconds. The vote came despite claims by the Arizona Department of Transportation that permitting these kinds of signs along state freeways and roads violates federal laws. The violation, according to ADOT lobbyist Kevin Biesty, could cost Arizona \$50 million in federal aid. (From the Arizona Daily Star, March 12, 2003: Web link not available.)

- The above bill (SB1138) contradicted efforts represented by tough Flagstaff and Coconino County ordinances that control light pollution and another bill passed by the Legislature that requires shielded lights for new state buildings. Flagstaff is a hub for astronomical research in Arizona. Officials said that although illuminated billboards are either banned or strictly regulated under Coconino County and Flagstaff ordinances, passage of the bill could embolden the outdoor advertising industry to take a run at local regulations. (From the *Tucson Citizen*, April 24, 2003: http://www.tucsoncitizen.com/breaking/archive/4_24_03dark_skies.html)

DRIVER DISTRACTION

Commercial EBBs are designed to “catch the eye” of drivers.^{*} Their presence may distract drivers from concentrating on the driving task and the visual surrounds.²

^{*}From Outdoor Advertising Association of America Web site at <http://www.oaaa.org/outdoor/>:

1. ... Today the advances in computer imaging and reproduction make even photographic renditions absolutely breathtaking regardless of size. Such advances have not only allowed greater durability but also entire new forms of outdoor to emerge: wallsapes, wrapped buildings, the conversion of construction sites into marketing events.
2. Technology has enabled virtually anything imaginable. The wonders out there go far beyond an oversized pretty picture. A medium that began as a simple two-dimensional sign can now talk to you (via short wave radio links), download data into your Palm Pilot (through a patented Street Beam device), connect you to the Internet (via souped-up taxi tops), and change as you pass by (through motion detectors). Add this to old-fashioned LED boards and the “no-holds-barred” street theater of Times Square and, well, you get the picture.
3. ... Outdoor IS the message, and as such will always be the last mass medium, a sure fire way to get noticed, to draw attention, ultimately to sell... which is, after all, outdoor’s raison d’etre. So as long as there are widgets in search of a buyer, outdoor will be out there, outdoing everything else!

²*Research Review of Potential Safety Effects of Electronic Billboards on Driver Attention and Distraction*- FHWA, Sept. 11, 2001- p. 17

<http://www.fhwa.dot.gov/realstate/elecbbbrd/elecbbbrd.pdf>

The safety consequences of distraction from the driving task can be profound.

In one study, five years (1995 to 1999) of national Crashworthiness Data System (CDS) data are analyzed to determine the role of driver distraction in traffic crashes and the specific sources of this distraction. Results show that 8.3 percent of the drivers were distracted at the time of their crash; after adjustment for the large percentage of drivers with unknown distraction status, the percentage rose to 12.9 percent. The most frequently cited sources of driver distraction were persons, objects or events outside the vehicle (29.4 percent of distracted drivers); adjusting the radio, tape or CD player (11.4 percent); and other occupants in the vehicle (10.9 percent). Other specific distractions (moving objects in vehicle, other objects brought into vehicle, adjusting vehicle or climate controls, eating and drinking, cell phones and smoking) were each cited in only 1 to 4 percent of the cases. The likelihood of being distracted and the source of distraction varied by driver age but not by gender.³

³abstract: “The Role of Driver Distraction in Crashes: An Analysis of 1995-1999 Crashworthiness Data System Data- Association for the Advancement of Automotive Medicine,” 2001

<http://199.79.179.82/sundev/detail.cfm?ANNUMBER=00923438&STARTROW=91&CFID=179748&CFTOKEN=35097404>

Treat et al. found that driver inattention and improper lookout increase the likelihood of crash occurrence and are major factors underlying the causes of crashes.⁴ According to Wang, et al., an analysis conducted by the National Highway Traffic Safety Administration (NHTSA) of causal factors of crashes showed that distraction by sources external to the vehicle accounted for 3.2 percent of the crashes. The external sources included people, events and non-specified objects.⁵ The NHTSA analysis did not identify the external objects, nor did it identify billboards as among the sources of distraction. However, the data suggest that, on occasion, external stimuli can be sufficiently distracting to drivers, causing or resulting in a crash.⁶

⁴*Tri-Level Study of the Causes of Traffic Accidents*

Treat, J.R.; Tumbas, N.S.; McDonald, S.T.; Shinar, D.; Hume, R.D.; Mayer, R.E.; Stanisfer, R.L.; and Castellan, N.J. [1979] Washington, D.C.: National Highway Traffic Safety Administration)

⁵*The Role of Driver Inattention in Crashes: New Statistics from the 1995 Crashworthiness Data System*

Wang, J., Knipling, R. and Goodman, M. [2000]

Obtained from the August 2000 Driver Distraction Internet Forum sponsored by the National Highway Traffic Safety Administration on the World Wide Web)

⁽⁶⁾*Research Review of Potential Safety Effects of Electronic Billboards on Driver Attention and Distraction*- FHWA, Sept. 11, 2001- p. 10
<http://www.fhwa.dot.gov/realstate/elecbbbrd/elecbbbrd.pdf>

Research on driver search behavior in high and low volume intersections by Rahimi, Briggs and Thorn in 1990 suggests that higher volumes of traffic affect driver eye and head movements.⁷ The research indicates that the greater visual complexity associated with the high volume intersection required drivers to search the environment more than in the low volume intersections. It can be conjectured that additional visual stimuli, such as billboards, may add additional demand to driver workload in high-volume intersections.⁸

⁽⁷⁾*A Field Evaluation of Driver Eye and Head Movement Strategies toward Environmental Targets and Distractors*
Rahimi, M., Briggs, R. and Thorn, D. [1990]
Applied Ergonomics, 21(4), pp. 267 to 274)

⁽⁸⁾*Research Review of Potential Safety Effects of Electronic Billboards on Driver Attention and Distraction*- FHWA, Sept. 11, 2001- p. 13
<http://www.fhwa.dot.gov/realstate/elecbbbrd/elecbbbrd.pdf>

Guidance on information processing time requirements comes from research on dynamic message signs, where drivers are reading unfamiliar messages. A study (conducted by Mast and Ballas in 1976) was carried out with drivers who were driving on a low-density highway, and it showed that 85 percent of them were able to read signs with word messages only at a rate of one major word per second or better. This means that under perfect conditions, a driver with 20/20 vision traveling during the day at 100 km/h (62 mph) on a freeway reading 14-inch letters has about nine seconds during which the sign text is legible, and therefore could cope with about nine words and/or symbols. At the other extreme, a driver with 20/40 vision traveling at 80 km/h (50 mph) at night on a major highway reading six-inch letters could cope with only one word and/or symbol. Other factors that affect the time taken to read any message are the driver workload (that is, the number of tasks the driver must perform simultaneously), the message familiarity and display format. For driver workload, it is important that the message must be legible at a distance that allows sufficient exposure time for drivers to attend to the complex driving situation and glance at the sign a sufficient number of times to read and comprehend the message.⁹

⁽⁹⁾Toronto Staff Report- Feb. 6, 2001- p. 4
<http://www.city.toronto.on.ca/legdocs/2001/agendas/committees/wks/wks010221/it002b.pdf>

Numerous states have attempted to identify a relationship between EBBs and safety by using traffic conditions as a surrogate measure. The states of Nevada, Utah, Texas, New York, New Hampshire and Massachusetts reported no evidence of increased traffic safety problems after the installation of electronic information displays in their city centers and along their highways. Additionally, five state DOT personnel were asked if a crash relationship with EBBs existed in their states; the responses were that a relationship between crashes and EBBs was not identifiable. However, one belief is that EBBs are typically on congested roadways where drivers have time to look at the sign, so it is difficult to determine if the EBBs cause crashes, let alone traffic congestion.¹⁰

⁽¹⁰⁾*Research Review of Potential Safety Effects of Electronic Billboards on Driver Attention and Distraction*- FHWA, Sept. 11, 2001- p. 8
<http://www.fhwa.dot.gov/realstate/elecbbbrd/elecbbbrd.pdf>

AVENUES FOR RESEARCH

It would be beneficial to measure the effect that EBBs have on driver distraction. The FHWA report suggests methodologies involving:

The Peripheral Detection Task

Olsson and Burns describe a peripheral detection task (PDT) that is designed to measure visual distraction and driver mental workload. This study included measures of reaction time and correct detection rate for drivers who were asked to report the presence of an LED dot shown briefly at slightly different locations on a windshield while: 1) driving on country roads and a motorway and 2) performing a secondary task while driving. The dots were projected 11 to 23 degrees to the left of the straight-ahead view and two to four degrees above the horizon. This location approximates the visual angle that corresponds to a pedestrian or some roadside signs. Statistically significant results indicated that a CD manipulation task and a backwards counting task required a longer performance time and resulted in fewer correct detections than the baseline driving task.

Since these drivers missed more targets when performing a secondary task and because it took longer to report the targets that were spotted, the PDT may be useful in assessing the distractibility of in-vehicle systems. If the PDT can be applied to in-vehicle systems, it may also be applicable to stimuli external to the vehicle such as EBB and tri-vision signs.¹¹

(¹¹*Measuring Driver Visual Distraction with a Peripheral Detection Task*
Olsson, S. and Burns, P.C. [2000], Obtained from the August 2000 National Highway Traffic Safety Administration Driver Distraction Internet Forum on the World Wide Web)

Work zones

Research about the effects of EBBs in work zones on safety should be performed, since the presence of additional visual distractions may elevate the risk of driver distraction and unsafe driving. Different roadway characteristics exert varying demands upon driver attention and skill. Particular roadway configurations and their characteristics may be more or less suitable for EBBs, and are important to consider when evaluating the safety effects of EBBs. The following roadway characteristics have special considerations relative to the issue of distraction and safety: horizontal and vertical curves, interchanges and intersections, and work zones. Whatever the reason for current selection of improper speed in a work zone, it is possible that the presence of an EBB or tri-vision sign would aggravate the problem.¹²

(¹²*Research Review of Potential Safety Effects of Electronic Billboards on Driver Attention and Distraction*- FHWA, Sept. 11, 2001- pp. 21 to 23
<http://www.fhwa.dot.gov/realstate/elecbbbrd/elecbbbrd.pdf>)

CMS

Although the CMS is restricted to providing roadway-related information, its legibility requirements may be relevant to the design of the simpler EBB. One event that can be considered a distraction occurs when a driver passes a sign where the text has poor legibility. The weakness in legibility may be due to poor character font design, improper spacing of letters or other factors. However, if the information is of sufficient interest, the driver may try to read all of the text anyway. Such a decision could take time away from the driving task, thus increasing crash risk. If on the other hand the sign had text that met legibility standards, less effort would be required to read the sign. Although this situation is a more subtle distraction than that due to perceived motion in a sign, it still could present potential for crash risk. Garvey and Mace provide draft guidelines for the design of the elements and characters that compose a word and word groupings on a CMS, in which the character font is composed of light emitting elements.¹³

(¹³*Changeable Message Sign Visibility*
Garvey, P.M. and Mace, D.J. [1996]
Report No. FHWA-RD-94-077. Washington, D.C: Federal Highway Administration)

The MUTCD (39) Section 2E-21 (applicable to CMS for use on freeway and expressway mainlines), states that a CMS should display no more than three lines of text. There should be a maximum of 20 characters per line. An analysis of these numbers for the simpler EBB displays, in conjunction with analyses of exposure times, may be useful.¹⁴

(¹⁴*Research Review of Potential Safety Effects of Electronic Billboards on Driver Attention and Distraction*- FHWA, Sept. 11, 2001- pp. 21 to 23
<http://www.fhwa.dot.gov/realstate/elecbbbrd/elecbbbrd.pdf>)

Garvey and Mace examined CMSs to identify the features that contribute to their visibility. The authors provide guidelines that are aimed at improving the visibility of all CMSs, regardless of technology. Minimum luminance values are recommended for CMS visibility. In addition, they suggest that there should be a minimum luminous contrast between the unlighted and lighted elements on a CMS. Contrast orientation should always be positive, that is, the characters should be lighted against a dark or less luminous background. A negative contrast is likely to result in a 25 percent shorter legibility distance.¹⁵

(¹⁵*Research Review of Potential Safety Effects of Electronic Billboards on Driver Attention and Distraction*- FHWA, Sept. 11, 2001- p. 13
<http://www.fhwa.dot.gov/realstate/elecbbbrd/elecbbbrd.pdf>)

A TMC pooled-fund study is under way that will assess the impacts of dynamically displaying messages on CMS and recommend updates to the MUTCD regarding design, programming and operation of such applications. The objectives of the research include conducting multitask human factors laboratory studies or studies using a driver simulator to determine the effects of using these dynamic features: flashing an entire one-frame message, flashing one line of a one-frame message, and alternating one line of text and keeping two lines constant on a three-line sign.¹⁶

(¹⁶*Impacts of Using Dynamic Features to Display Messages on Changeable Message Signs*
TMC Pooled-fund Study- Current Projects
http://tmcdfs.ops.fhwa.dot.gov/cfprojects/new_detail.cfm?id=31&new=0)

Cellular phones

Although research into in-vehicle cellular telephone use does not currently appear to have direct application to EBBs or tri-vision signs, these analyses are ongoing and may still provide insights into the nature of driver distraction, the definition of distraction thresholds and approaches to minimizing distraction for safe driving. In each case, the application of a new technology raised concerns about driver distraction.¹⁷

(¹⁷*Research Review of Potential Safety Effects of Electronic Billboards on Driver Attention and Distraction*- FHWA, Sept. 11, 2001- p. 29
<http://www.fhwa.dot.gov/realestate/elecbbbrd/elecbbbrd.pdf>)

The relevance of information on cellular telephone use to EBBs lies in visual (glancing) and cognitive (mental engagement) behaviors. Viewing EBBs or using a telephone requires drivers to look away from the roadway for some period. Similarly, reading a sign could disrupt a driver's concentration, just as engaging in a telephone conversation might. According to Cain and Burris, hands-free telephone use carries about the same risk observed in hand-held use,¹⁸ and an NHTSA report cites that a telephone conversation is a factor in crashes more frequently than dialing.¹⁹ Cain and Burris believe that the type of conversation is significant in determining crash risk, and McKnight and McKnight believe that complex and intense conversation is the riskiest, and simple conversation is relatively risk-free.²⁰ Thus, becoming mentally preoccupied can be as distracting to a driver as manually operating a telephone or glancing away from the roadway.²¹

(¹⁸*Investigations of the Use of Mobile Phones While Driving*
Cain, A., and Burris, M. [1999]
Florida, USA: Center for Urban Transportation Research, University of South Florida)

(¹⁹*Traffic Safety Facts 1996: Young Drivers*
National Highway Traffic Safety Administration [1997] Washington, D.C.: National Highway Traffic Safety Administration)

(²⁰*The Effect of Cellular Phone Use Upon Driver Attention*
McKnight, J., and McKnight, A.S. [1991]
Landover, MD: National Public Services Research Institute)

(²¹*Research Review of Potential Safety Effects of Electronic Billboards on Driver Attention and Distraction*- FHWA, Sept. 11, 2001- p. 17
<http://www.fhwa.dot.gov/realestate/elecbbbrd/elecbbbrd.pdf>)